Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Кафедра програмного забезпечення комп'ютерних систем

SOFTWARE OF MULTIMEDIA SYSTEMS. PART 1. COMPUTER GRAPHICS

Syllabus

Details of the educational component	
Level of higher education	***First (Bachelor)***
Branch of knowledge	*12 Information Technologies*
Specialty	*121 Software Engineering*
Educational program	*Software Engineering of Multimedia and Information-Retrieval Systems*
Status of the educational component	*Normative*
Form of education	*Full-time*
A year of training	*3rd year, Spring semester*
The scope of the educational component	*Lectures: 36 academic hours, computer class: 18 academic hours, student's self-training: 81 academic hours.*
Semester control / control measures	*Exam, midterm test, quiz, calendar control*
Schedule of classes	*According to the schedule for the autumn semester of the current academic year (rozklad.kpi.ua)*
Language of instructions	*English*
Information about head of the course / teachers	*Lectures: DSc, assoc. prof. Yevgeniya Sulema, sulema@pzks.fpm.kpi.ua* *Computer class: PhD Oksana Shkurat, shkurat@pzks.fpm.kpi.ua*
Course location	Google classroom. Access is given to registered students.

Program of educational component

1. Description of the educational component, its purpose, subject of study and learning outcomes

The purpose *of studying the discipline (credit module) "Software support of multimedia systems. Part 1. Computer graphics" is the formation of students' ability to independently develop software that implements elements of computer graphics, as well as to use third-party software to create elements of computer graphics.*

The subject *of the discipline (credit module) "Software support of multimedia systems. Part 1. Computer graphics" is a mathematical and algorithmic support for the processes of presentation, transformation and reproduction of graphic information.*

Studying the discipline (credit module) "Software support of multimedia systems. Part 1. Computer graphics" allows students to develop the ***competencies*** *necessary for solving practical tasks of professional activity related to the development and use of computer graphics elements in software:*

PC19 – Ability to develop software for multimedia and mulsemedia systems;

PC20 – Ability to apply the acquired fundamental mathematical knowledge to develop calculation methods in the multimedia and information retrieval systems creation.

The program results *of the discipline (credit module) "Software support of multimedia systems. Part 1. Computer graphics":*

PLO05 – To know and apply relevant mathematical concepts, domain methods, system and object-oriented analysis and mathematical modeling for software development;

PLO12 – To apply effective approaches to software design in practice;

PLO25 – To know and to be able to use fundamental mathematical tools in the algorithms construction and modern software development;

PLO26 – To be able to develop and use methods and algorithms for the mathematical problems approximate solution during the multimedia and information retrieval systems design;

PLO28 – To know the mathematical and algorithmic basics of computer graphics and to be able to apply them to develop multimedia software;

PLO29 – To know the principles of using the latest multimedia technologies, mulsemedia and immersive technologies;

PLO31 – To be able to identify, analyze and document software requirements for multimedia and information retrieval systems;

PLO42 – To know the basic presentation models of textual and multimedia information and methods of its pre-processing for use in the design of information retrieval systems;

PLO43 – To know and be able to use in practice the existing software resources and libraries for processing of textual information and multimedia data in information retrieval systems.

2. Pre-requisites and post-requisites of the educational component (place in the structural and logical scheme of training according to the relevant educational program)

Successful study of the discipline (credit module) "Software support of multimedia systems. Part 1. Computer graphics" precedes the study of the discipline "Mathematical Support of Multimedia and Information Retrieval Systems", "Programming" of the curriculum of bachelor's training in the specialty 121 Software engineering.

Received during the assimilation of the discipline (credit module) "Software support of multimedia systems. Part 1. Computer graphics" theoretical knowledge and practical skills are necessary for studying the discipline (credit module) "Software support of multimedia systems. Part 2. XR-applications" of the bachelor's training plan and the discipline "Multimedia interfaces and 3D visualization" of the master's training plan in the specialty 121 Software engineering.

3. Content of the academic discipline

Discipline (credit module) "Software support of multimedia systems. Part 1. Computer graphics" involves the study of the following topics:

Topic 1. Introduction to computer graphics

Topic 2. Color models

Topic 3. Rasterization algorithms of graphic primitives

Topic 4. Geometric transformations and projections

Topic 5. Algorithms of cutting

Topic 6. Algorithms for removing invisible lines and surfaces

Topic 7. Coloring algorithms

Modular control work

Exam

4. Educational materials and resources

Basic literature:

1. Educational and methodological materials for the educational component "Software support of multimedia systems. Part 1. Computer graphics".
Use to master practical skills in the discipline. The materials are in Google classroom. Access is granted to registered students.

Additional literature:

1. Nathan Carter. Introduction to the Mathematics of Computer Graphics. American Mathematical Society. 2016. 462 p.
Use to deepen the knowledge in the discipline. Materials are available on the Internet.

2. Steve Marschner, Peter Shirle. Fundamentals of Computer Graphics. CRC Press, 2021, 700 p.
Use to deepen the knowledge in the discipline. Materials are available on the Internet.

3. John Vince. Calculus for Computer Graphics. Springer, 2019, 320 p.
Use to deepen the knowledge in the discipline. Materials are available on the Internet.

4. Leen Ammeraal. Computer Graphics for Java Programmers. Springer, 2017. 400 p.
Use to master the practical skills in the discipline. Materials are available on the Internet.

Educational content

5. Methods of mastering the educational component

No.	Type of training session	Description of the training session
	Topic 1. Introduction to computer graphics	
1	*Lecture 1. Computer image processing*	*Fields of application of computer graphics. Basic definitions. Problems of computer image processing. Classification of images.* *Task for self-training: item 6, No. 1.*
2	*Computer class 1. Working with graphic primitives of the JavaFX library*	*Task: Create an image according to the variant number using the graphic primitives of the JavaFX library.* *Task for self-training: item 6, No. 2, 29.*
	Topic 2. Color models	
3	*Lecture 2. Hardware-oriented color models*	*Physical principles of the formation of shades. Additive and subtractive methods of forming shades. RGB color model. CMY and CMYK color models. YIQ color model.* *Task for self-training: item 6, No. 3, 30.*
4	*Lecture 3. Human-oriented and abstract color models*	*HSV color model. HLS color model. Convert between RGB and HSV models. CIE XYZ color model. Chromatic diagram.* *Task for self-training: item 6, No. 4.*
5	*Computer class 2. Creating images and their animation in Java2D*	*Task: create an image using the primitives of the Java2D library and animate it according to the variant number.* *Task for self-training: item 6, No. 5.*

Topic 3. Rasterization algorithms of graphic primitives		
6	*Lecture 4. Raster and vector graphics*	*Comparative analysis of raster and vector graphics. Concept of raster and connectivity. Raster types. Modeling a hexagonal raster.* *Task for self-training: item 6, No. 6.*
7	*Lecture 5. Segment generation algorithms*	*Algorithms based on the equations of a straight line. Algorithm of the usual DDA. Algorithm of asymmetric DDA. Bresenham's algorithm for segments. Improvement of the quality of visualization of lines.* *Task for self-training: item 6, No. 7, 31.*
8	*Computer class 3. Working with .bmp files with JavaFX (Part 1)*	*Task: using JavaFX library classes to implement procedures for reading, processing and saving a .bmp image, in order to use it further to create the trajectory of object movement.* *Task for self-training: item 6, No. 8.*
9	*Lecture 6. Circle generation algorithms*	*Algorithms based on circle equations. Bresenham's algorithm for circles.* *Task for self-training: item 6, No. 9, 32.*
10	*Lecture 7. Algorithms for generating Bézier curves*	*Mathematical definition of the nth-order Bézier curve. Curves of the 3rd order. Control points of Bézier curves. Properties of Bézier curves.* *Task for self-training: item 6, No. 10.*
11	*Computer class 3. Working with .bmp files with JavaFX (Part 2)*	*Task: With the help of JavaFX primitives, depict the character according to the variant and perform its 2D animation using a .bmp file.* *Task for self-training: item 6, No. 11.*
Topic 4. Geometric transformations and projections		
12	*Lecture 8. Two-dimensional transformations*	*Two-dimensional transformations in homogeneous coordinates. Basic transformations: shift, scale, rotate. Composition of two-dimensional transformations.* *Task for self-training: item 6, No. 12, 33.*
13	*Lecture 9. Three-dimensional transformations*	*Three-dimensional transformations in homogeneous coordinates. Basic transformations: shift, scaling, rotations. Inverse transformations.* *Task for self-training: item 6, No. 13, 34.*
14	*Computer class 4. Building 3D objects using Java3D and animating them (part 1)*	*Task: Using the tools provided by the Java3D library, build a 3D object according to the version number.* *Task for self-training: item 6, No. 14.*
15	*Lecture 10. Projections*	*Classification of flat projections. Parallel projections. Orthographic projection. Isometric projection. Axonometric projections. Central projections.* *Task for self-training: item 6, No. 15.*

Midterm Test		
Topic 5. Algorithms of cutting		
16	*Lecture 11. Basic cutting algorithms*	*Classification of cutting algorithms. Algorithms with coding. Cohen-Sutherland algorithm.* *Task for self-training: item 6, No. 16, 35-36.*
17	*Computer class 4. Building 3D objects using Java3D and animating them (part 2)*	*Task: Use the tools provided by the Java3D library to animate a 3D scene.* *Task for self-training: item 6, No. 17.*
18	*Lecture 12. Algorithms of clipping for windows of arbitrary shape*	*Algorithms based on parametric equations. Cyrus-Beck algorithm. Decomposition of non-convex cutting windows.* *Task for self-training: item 6, No. 18, 37.*
Topic 6. Algorithms for removing invisible lines and surfaces		
19	*Lecture 13. Algorithms performed in image space*	*Classification of methods for removing invisible parts of objects. The "floating horizon" algorithm. Z-buffer algorithm.* *Task for self-training: item 6, No. 19, 38.*
20	*Computer class 5. Import, process and manipulate 3D models in Java3D*	*Task: Import 3D object models of variant-defined formats and create realistic object animation.* *Task for self-training: item 6, No. 20.*
21	*Lecture 14. Roberts' algorithm*	*Stages of the Roberts' algorithm. Formation of the object matrix. Removing edges that are shielded by other objects in the scene.* *Task for self-training: item 6, No. 21.*
Topic 7. Coloring algorithms		
22	*Lecture 15. Color filling algorithms*	*Classification of coloring algorithms. Algorithm of sequential coloring. Algorithm of painting from the starting point.* *Task for self-training: item 6, No. 22, 39.*
23	*Computer class 6. Animating 3D Objects Using Java3D (Part 1)*	*Task: Using Java3D library classes, import 3D models by option and create a 3D scene.* *Task for self-training: item 6, No. 23.*
24	*Lecture 16. Color calculation algorithms (part 1)*	*Components of the rendering process. Lighting calculation. Lighting models. A model based on Lambert's law. Phong's model. Calculation of shadows. Flat shading. Gouraud's method. Phong's method. The method of ray casting.* *Task for self-training: item 6, No. 24, 40.*
25	*Lecture 17. Color calculation algorithms (part 2)*	*Ray tracing method. Radiosity method. Method of photon maps. Texturing algorithms. Procedural texturing.* *Task for self-training: item 6, No. 25.*

26	*Computer class 6. Animating 3D Objects Using Java3D (Part 2)*	*Task: Animate 3D objects with the help of the Java3D library. Task for self-training: item 6, No. 26.*
Exam		

6. Student's self-training

The discipline (credit module) "Software support of multimedia systems. Part 1. Computer graphics" is based on self-training for classroom classes on theoretical and practical topics.

No.	*The topic assigned for self-training*	*Number of hours*	*Literature*
1	*Preparation for the lecture 1*	*1*	*1*
2	*Preparation for the computer class 1*	*1,5*	*1*
3	*Preparation for the lecture 2*	*1*	*1*
4	*Preparation for the lecture 3*	*1*	*1*
5	*Preparation for the computer class 2*	*1,5*	*1*
6	*Preparation for the lecture 4*	*1*	*1*
7	*Preparation for the lecture 5*	*1*	*1*
8	*Preparation for the computer class 3 (part 1)*	*1,5*	*1*
9	*Preparation for the lecture 6*	*1*	*1*
10	*Preparation for the lecture 7*	*1*	*1*
11	*Preparation for the computer class 3 (part 2)*	*1,5*	*1*
12	*Preparation for the lecture 8*	*1*	*1*
13	*Preparation for the lecture 9*	*1*	*1*
14	*Preparation for the computer class 4 (part 1)*	*1,5*	*1*
15	*Preparation for the lecture 10*	*1*	*1*
16	*Preparation for the lecture 11*	*1*	*1*
17	*Preparation for the computer class 4 (part 2)*	*1,5*	
18	*Preparation for the lecture 12*	*1*	
19	*Preparation for the lecture 13*	*1*	
20	*Preparation for the computer class 5*	*1,5*	
21	*Preparation for the lecture 14*	*1*	*1*
22	*Preparation for the lecture 15*	*1*	*1*
23	*Preparation for the computer class 6 (part 1)*	*1,5*	*1*
24	*Preparation for the lecture 16*	*1*	*1*
25	*Preparation for the lecture 17*	*1*	*1*
26	*Preparation for the computer class 6 (part 2)*	*1,5*	*1*
27	*Preparation for the midterm test*	*4*	*1*

28	*Preparation for the exam*	*30*	*1*
29	*Getting started with JavaFX in Eclipse. Download, install and configure JavaFX*	*2*	*1*
30	*Hardware-oriented color models. Color coding*	*1*	*1*
31	*Segment generation algorithms. Comparative analysis of segment generation algorithms.*	*1*	*1*
32	*Circle generation algorithms. Comparative analysis of algorithms for generating circles and ellipses.*	*1*	*1*
33	*Two-dimensional transformations. Equation of a straight line on a plane. Analytical presentation of curves and surfaces.*	*1,5*	*1*
34	*Three-dimensional transformations. Reflection in space. Three-dimensional rotation around an arbitrary axis.*	*1*	*1*
35	*Basic cutting algorithms. Curves and surfaces. Bilinear surfaces.*	*1*	*1*
36	*Basic cutting algorithms. Determination of convexity of polygons. Clipping with a convex polygon. Decomposition of non-convex polygons. Clipping polygons.*	*2*	*1*
37	*Algorithms of clipping for windows of arbitrary shape. Inverse transformations. Derivation of the reverse rotation formula.*	*2*	*1*
38	*Algorithms performed in image space. Special cases of projection. Prospective views.*	*1*	*1*
39	*Color filling algorithms. Comparative analysis and optimization of coloring algorithms.*	*1*	*1*
40	*Color calculation algorithms. Methods of eliminating gradation (anti-aliasing).*	*2*	*1*

Policy and control

7. Policy of academic educational component

- *Rules of behavior in classes: activity, respect for those present.*
- *Adherence to the policy of academic integrity.*
- *Rules for protecting the works of the computer workshop: the works must be done according to the option of the student, which is determined by his number in the group list.*
- *Rules for assigning incentive points: incentive points can be awarded for a creative approach in the performance of computer workshop works (maximum number of points for all works – 2 points).*

8. Rating system for evaluating learning outcomes

During the semester, students complete 6 computer class tasks. The maximum number of points for each computer class task: 5 points.

Points are awarded for:
- quality of laboratory work (computer class): 0-3 points;
- answer during the defense of laboratory work (computer class): 0-2 points.

Performance evaluation criteria:
3 points - the work is done with quality, in full;
2 points – the work is completed in full, but contains minor errors;
1 point – the work contains errors;
0 points – the work contains significant errors or is borrowed.

Answer evaluation criteria:
2 points – the answer is complete, well-argued;
1 point – there are errors in the answer;
0 points - there is no answer or the answer is incorrect.

The maximum number of points for performing and defending computer tasks:
5 points × 6 comp. tasks = 30 points.

During the semester, quiz on the topics of past lectures take place at the lectures. Maximum points for quiz: 5 points.

The assignment for the midterm test consists of 3 questions (problems). The answer to each question is evaluated by 5 points.

Evaluation criteria for test questions:
5 points – the answer is correct, the calculations are completed in full;
4 points – the answer is correct, but not very well supported by calculations;
3 points - in general, the answer is correct, but has flaws;
2 points – there are minor errors in the answer;
1 point – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.

The maximum number of points for the midterm test:
5 points × 3 questions = 15 points.

The rating scale for the course is equal to:

$R = R_S + R_E$ = 50 points + 50 points = 100 points.

R_S = 30 points + 5 points + 15 points = 50 points.

Calendar control: is carried out twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements.

At the first certification (8th week), the student receives "credited" if his current rating is at least 12 points (50% of the maximum number of points a student can receive before the first certification).

At the second certification (14th week), the student receives "passed" if his current rating is at least 20 points (50% of the maximum number of points a student can receive before the second certification).

Semester control: exam.

A necessary condition for admission to the exam is the completion and defense of all the tasks of the computer classes.

The exam sheet contains 3 questions: 2 theoretical and 1 practical. The answer to each theory question is worth 15 points, and the answer to a practical question is worth 20 points.

Evaluation criteria for each theoretical question:
14-15 points – the answer is correct, complete, well-argued;
11-13 points – the answer is correct, detailed, but not very well argued;
8-10 points - in general, the answer is correct, but has flaws;
5-7 points – there are minor errors in the answer;
1-4 points – there are significant errors in the answer;
0 points - there is no answer or the answer is incorrect.

Evaluation criteria for a practical question:
18-20 points - the answer is correct, the calculations are completed in full;
14-17 points - the answer is correct, but not very well supported by calculations;
9-13 points - in general, the answer is correct, but has flaws;
5-8 points – there are minor errors in the answer;
1-4 points – there are significant errors in the answer;

0 points - there is no answer or the answer is incorrect.

The maximum number of points for the exam:
15 points × 2 theory questions + 20 points × 1 theory question = 50 points.

Table of correspondence of rating points to grades on the university scale:

Scores	*Rating*
100-95	Excellent
94-85	Very Good
84-75	Good
74-65	Satisfactory
64-60	Fair
Less than 60	Unsatisfactory
Admission conditions not met	Not allowed

The syllabus prepared by DSc, assoc. prof. Yevgeniya Sulema.

Adopted by Computer Systems Software Department (protocol № 12 from 26.04.23)

Approved by the Faculty Board of Methodology (protocol № 10 from 26.05.23)